Impacts of Biochar Amendments on Soil Microbial Community Activity and Structure

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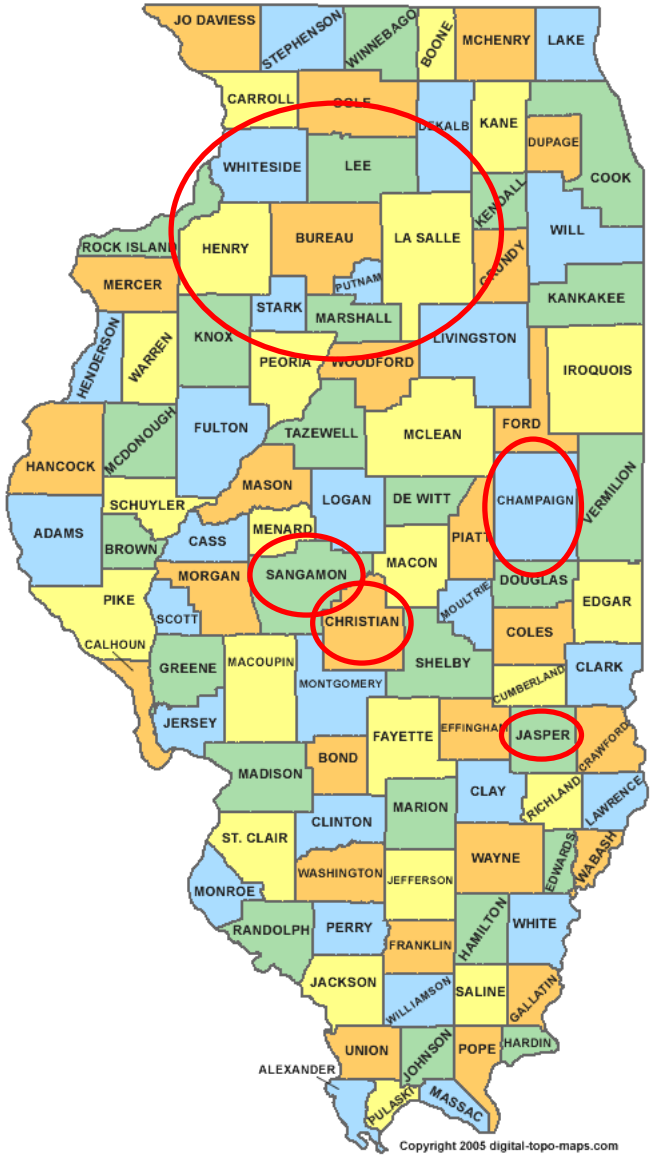
1 LOYOLA UNIVERSITY CHICAGO

3 USDA ARS
United States Department of Agriculture
Agricultural Research Service

Soils

	Soil	Location
1	Alvin	Northern IL
2	Bluford A	Jasper Co.
3	Cisne A	Jasper Co.
4	Cisne E	Jasper Co.
5	Drummer	U of I S. Farm
6	Fayette	Sangamon Co.
7	Huey	Jasper Co.
8	Ipava	Christian Co.
9	Oakville	Northern IL
10	Osco	Christian Co.
11	Swygert	Northern IL



Soil Characteristics

Soil	pH	OM %	CEC meq/100g	Phosphorus ppm	Potassium ppm	Magnesium ppm	Calcium ppm	Texture
Alvin	**4.8**	**1.2**	5.4	30	43	62	450	Loamy Sand
Bluford A	6.2	1.7	10.4	97	110	138	1543	Silt Loam
Cisne A	6.2	2.3	15.5	**108**	184	198	2317	Silt Loam
Cisne E	5.0	1.6	15.7	12	89	174	1520	Silt Loam
Drummer	**7.6**	**6.7**	23.0	101	**343**	425	**3712**	Silt Loam
Fayette	6.1	3.1	13.2	9	92	358	1640	Silt Loam
Huey	5.9	1.8	12.2	89	118	102	1793	Silt Loam
Ipava	6.0	2.5	14.1	36	117	179	2014	Silt Loam
Oakville	5.0	2.0	**2.6**	47	**42**	**44**	**202**	Sand
Osco	5.8	3.1	14.8	**7**	151	304	1835	Silt Loam
Swygert	6.3	4.1	**23.2**	73	230	**785**	2754	Clay Loam

Biochar

- Corn Stover
  1. Pyrolysis
  2. Gasification
  3. Burnt
  4. Unmodified (Green)
- Wood
  5. Pyrolysis
- Miscanthus
  6. Pyrolysis

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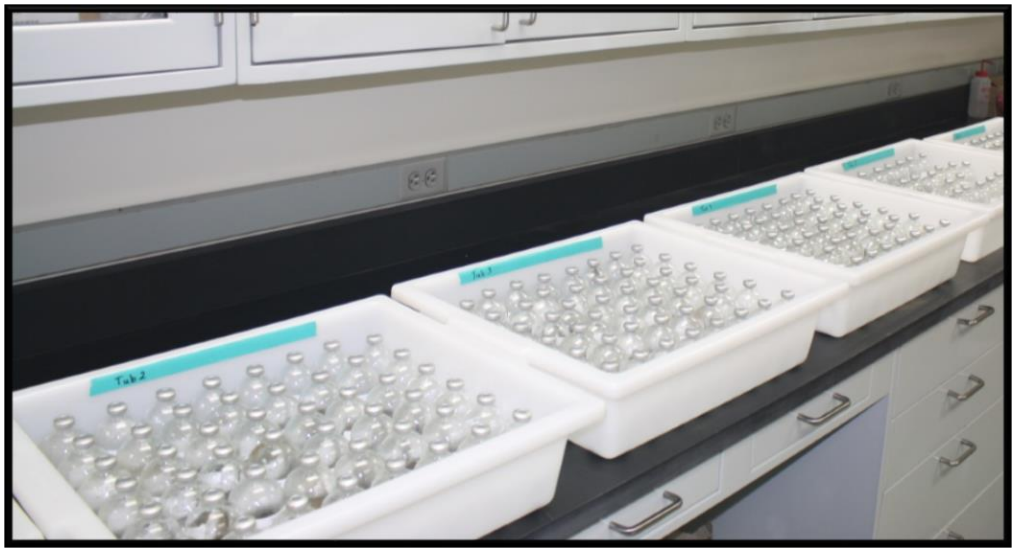
Soil / Biochar Incubations

- 11 soils
- 6 Biochars
- Three treatments:
  - Control (No Biochar)
  - 1% Biochar
  - 5% Biochar

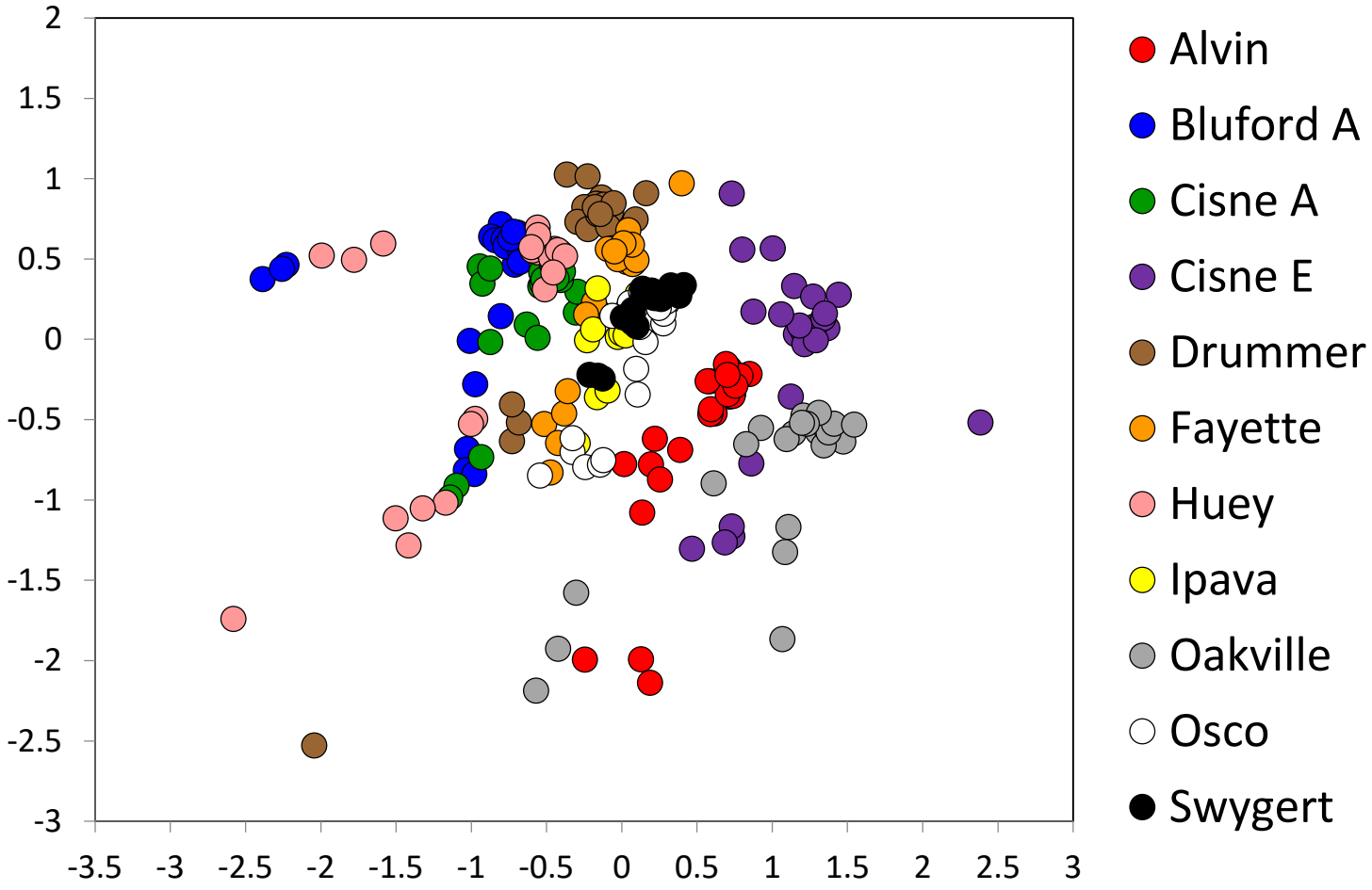


- Three replicate bottles per treatment (5g soil per bottle)
- Incubated at room temp in lab for 60 days
- Headspace gas samples collected at 10 time points during incubation to assess greenhouse gas fluxes (CO_2, N_2O and CH_4)
- After 60 days soils were collected for microbial analysis

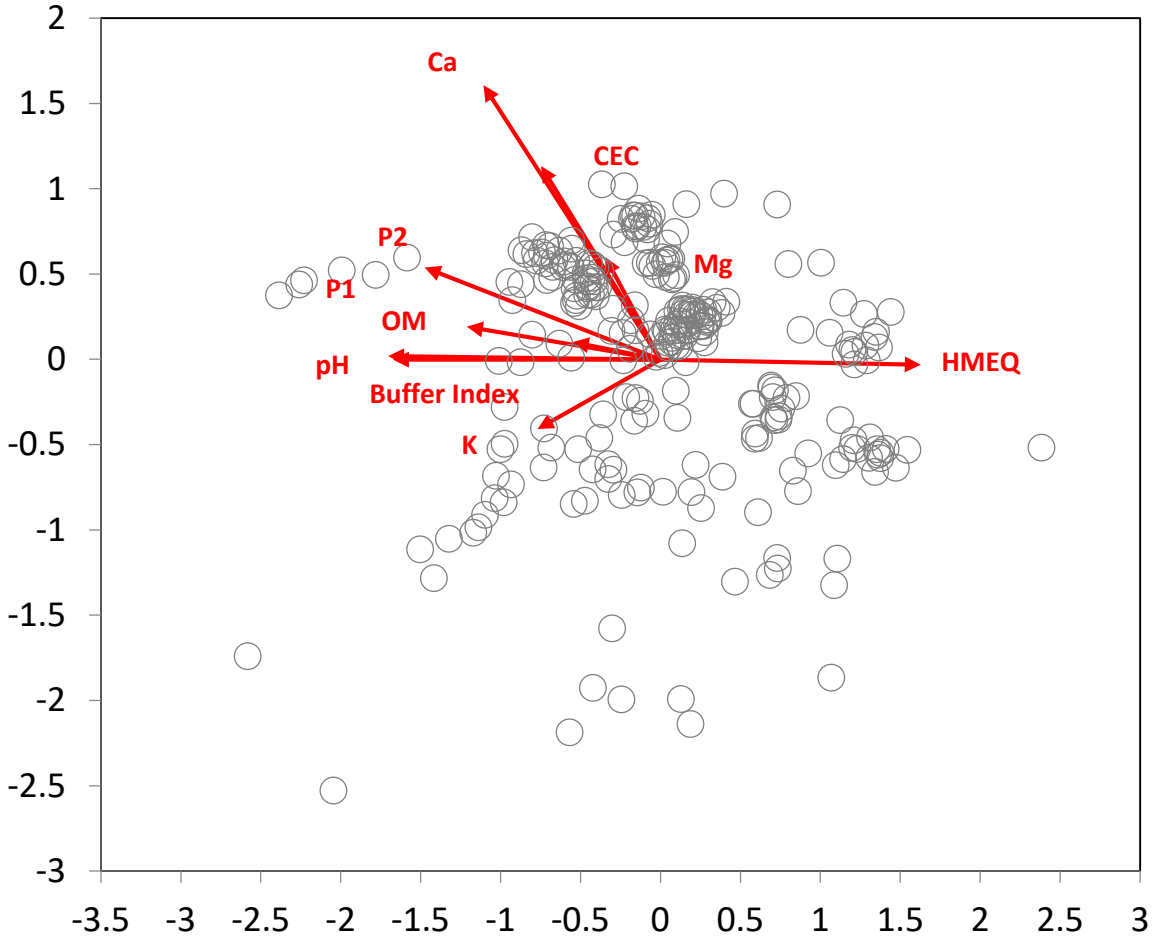
Bacterial Community Composition

- DNA was extracted from soils
  - Using MoBio Power Soil 96 Well Soil DNA Kit
- Bacterial 16S rRNA genes sequenced
  - Primers 515F and 806R used to amplify ~250 bp region of 16S rRNA genes
  - Amplicons were sequenced in a paired end format using the **Illumina MiSeq platform**
- DNA sequence data analyzed w/ MOTHUR
  - Paired reads were assembled and demultiplexed
  - Low quality sequences were removed
  - Sequences were aligned using the SILVA-compatible alignment database
  - Sequences were trimmed to a uniform length of 253 base pairs
  - Chimeric sequences were removed using Uchime
  - Sequences were classified by comparison to RDP training set
  - Non-bacterial sequences were removed
  - The entire dataset was randomly subsampled to **10,000 sequences per sample** -> **total of 2.69 Million Sequences**
  - Data were analyzed by non-metric multidimensional scaling (nMDS) using MOTHUR and PC-ORD

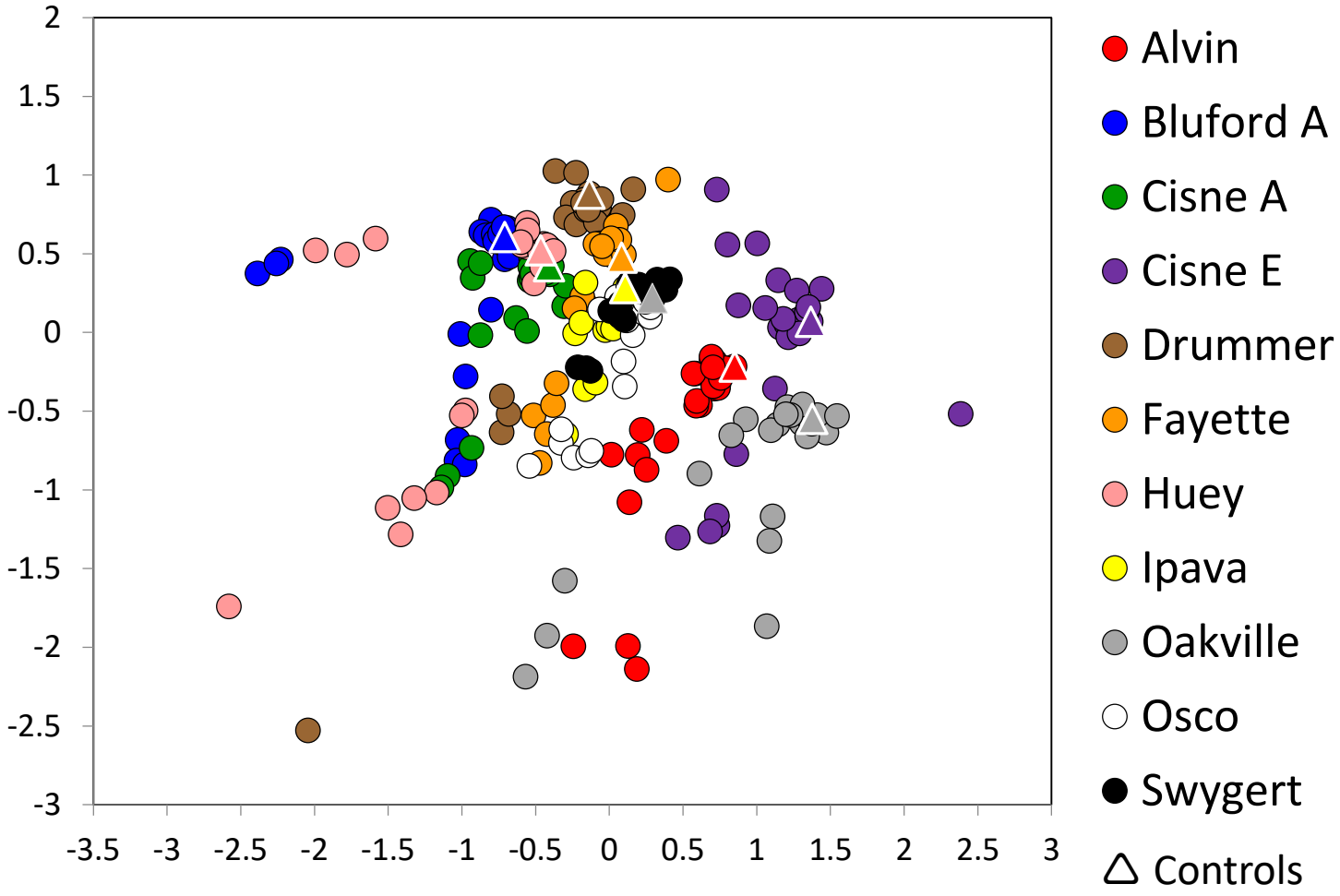
Effect of Soil Type



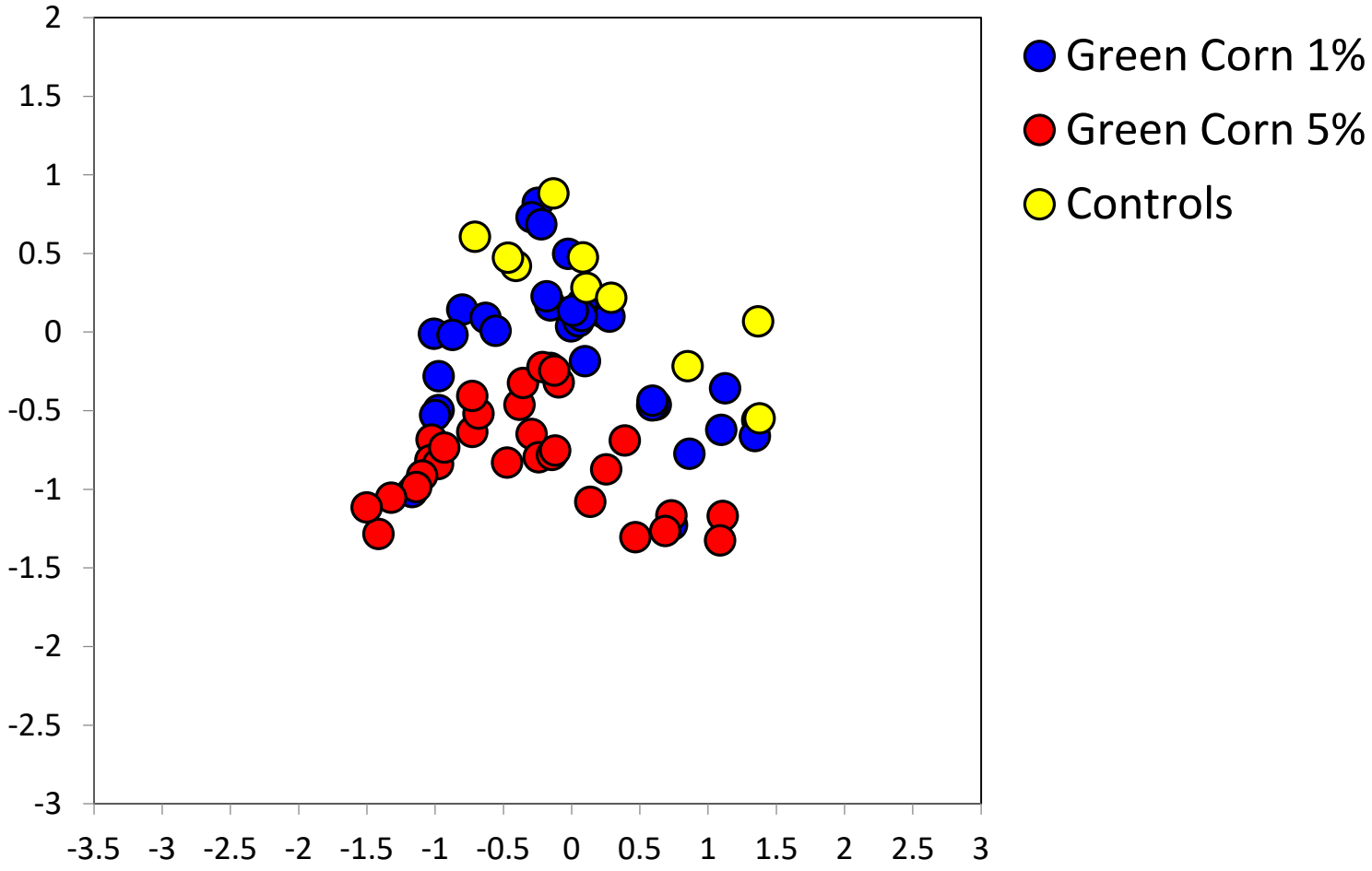
Correlations with Soil Properties



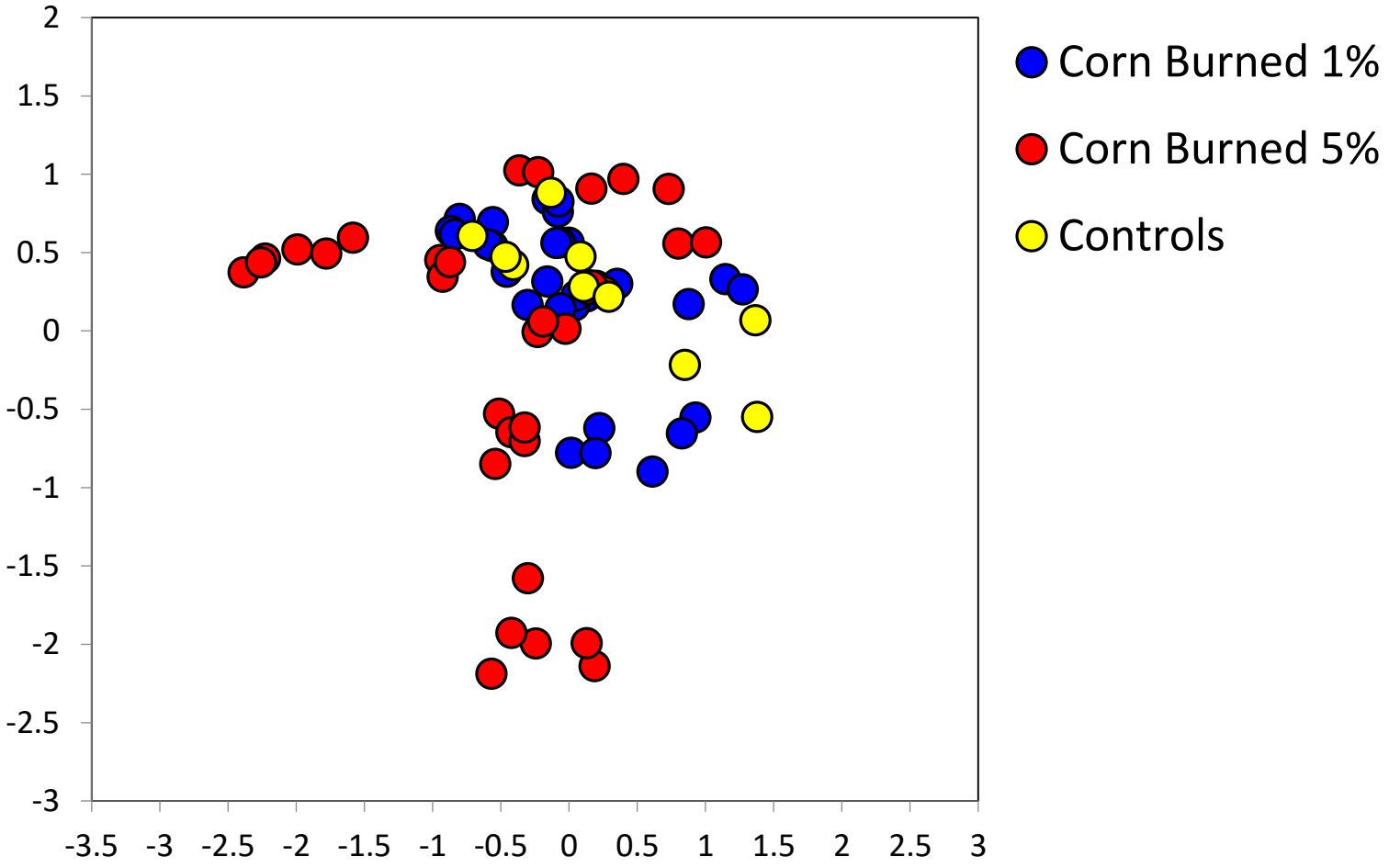
Effect of Treatments



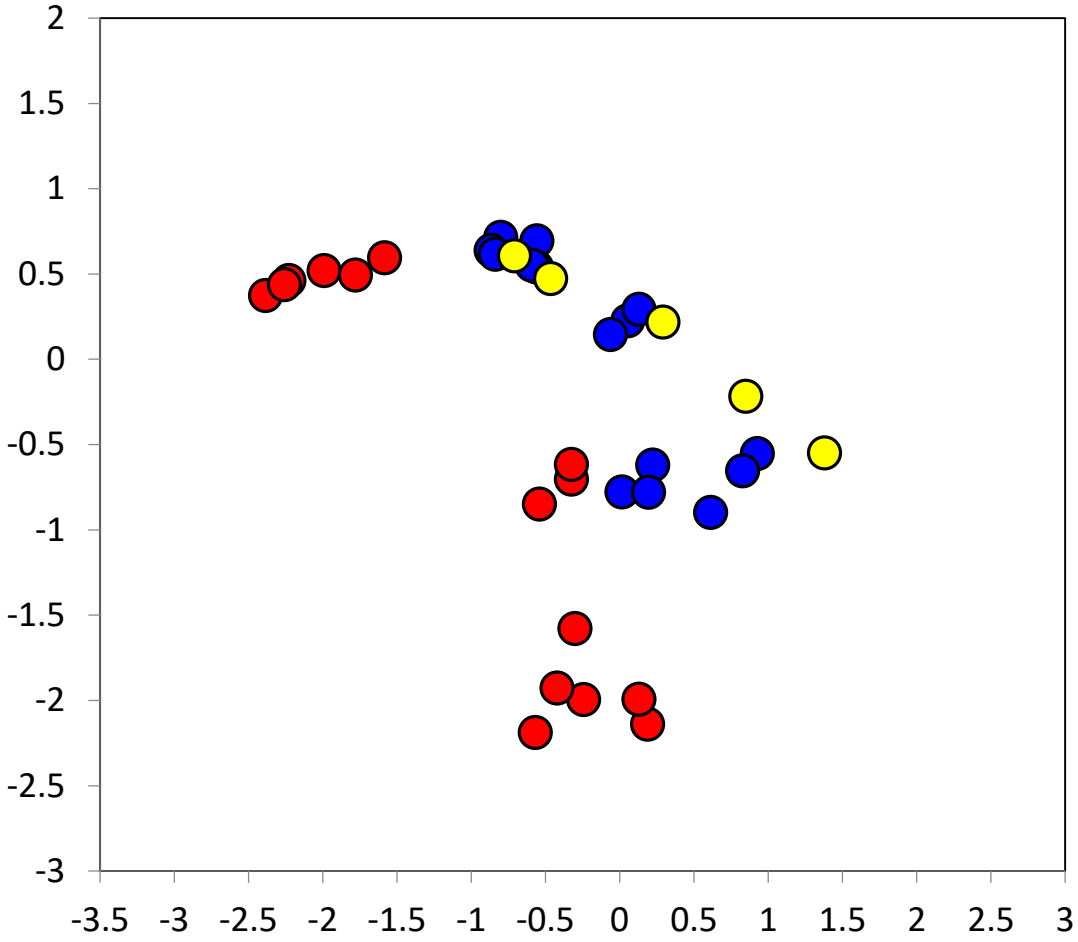
Effect of Green Corn Stover for All Soils



Effect of Burned Corn Stover for All Soils



Effect of Burned Corn Stover for Select Soils



Corn Burned 1%

Corn Burned 5%

Controls

Soils Included:

Alvin

Bluford A

Huey

Oakville

Osco

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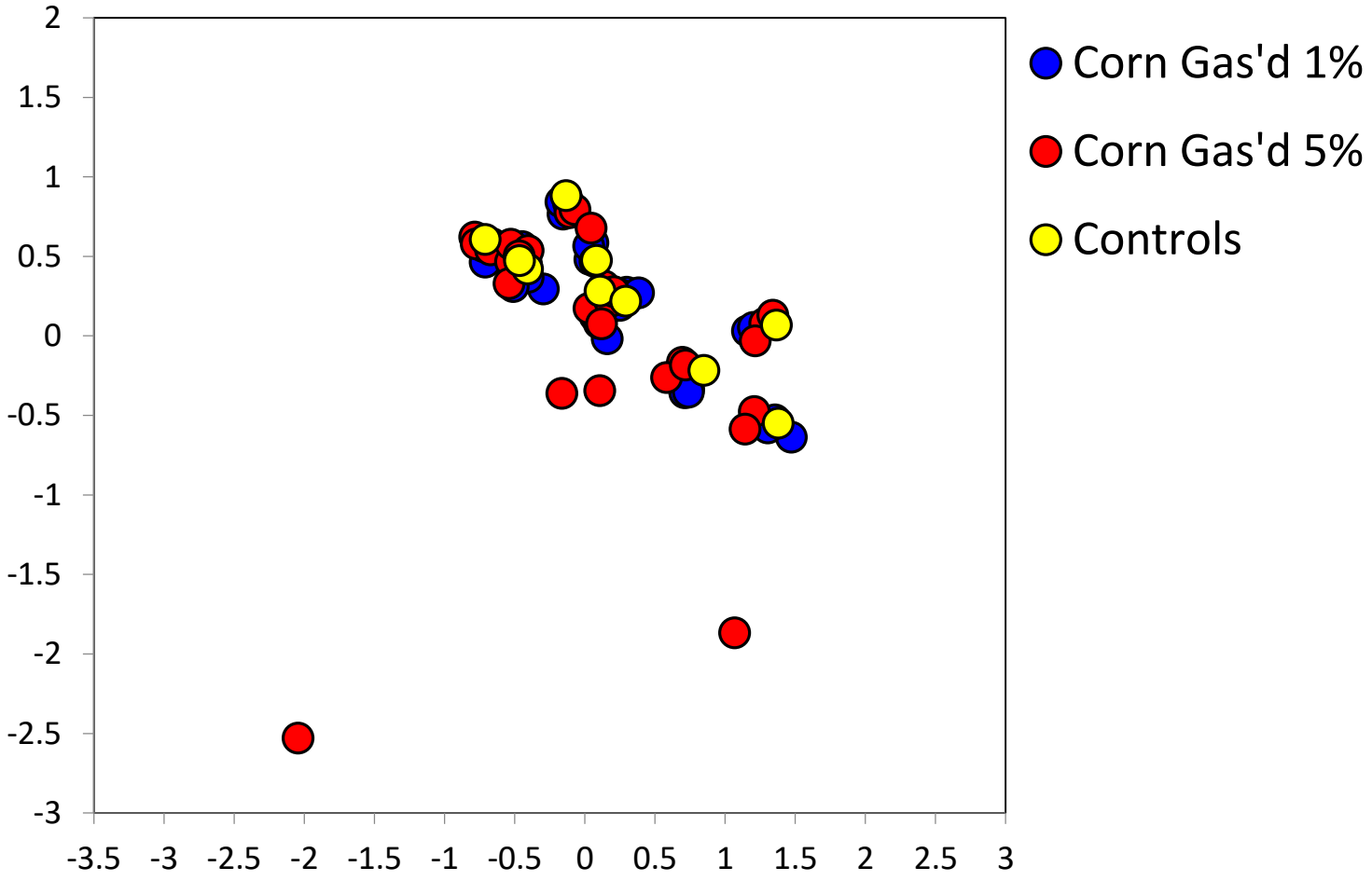
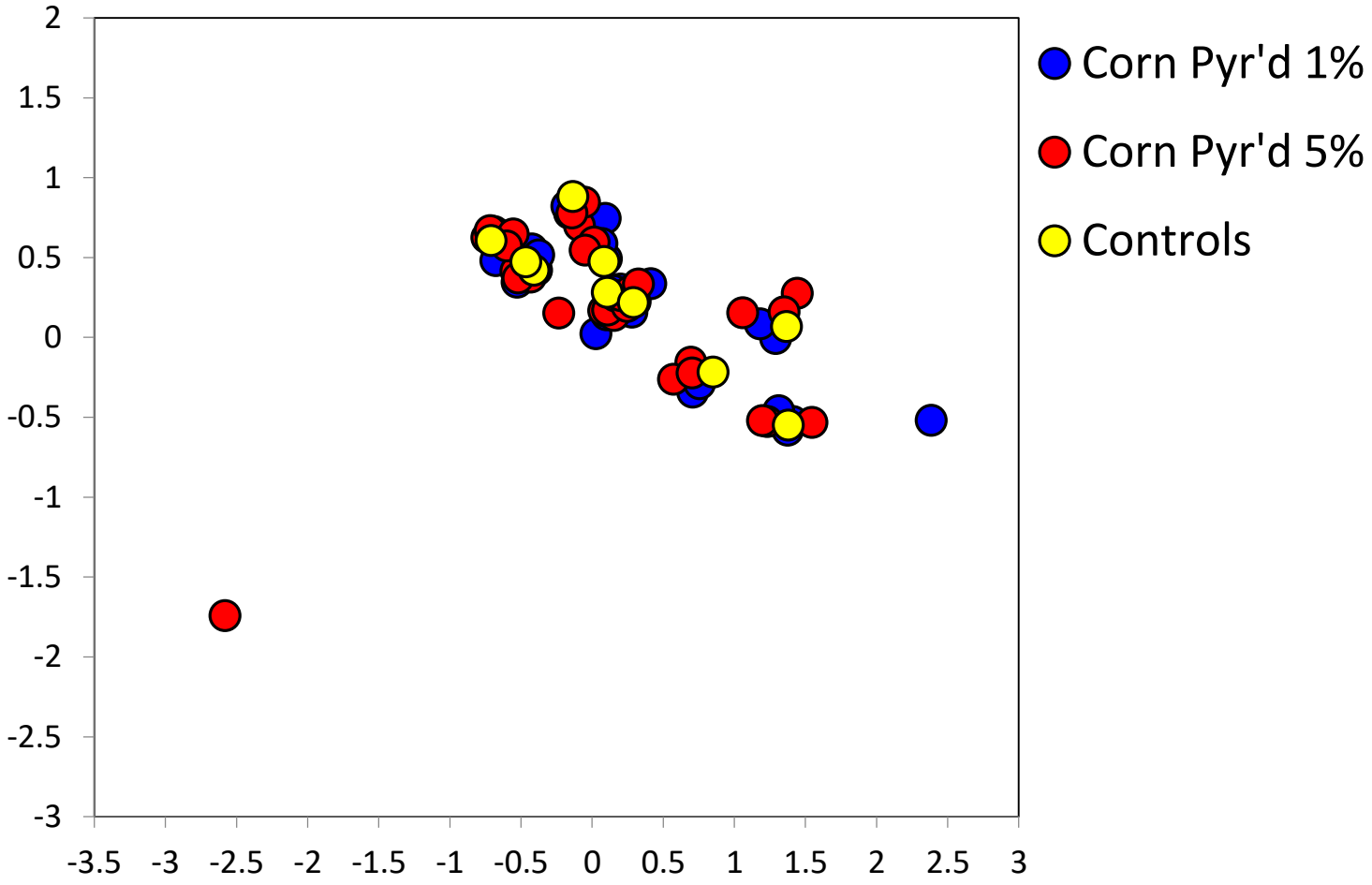
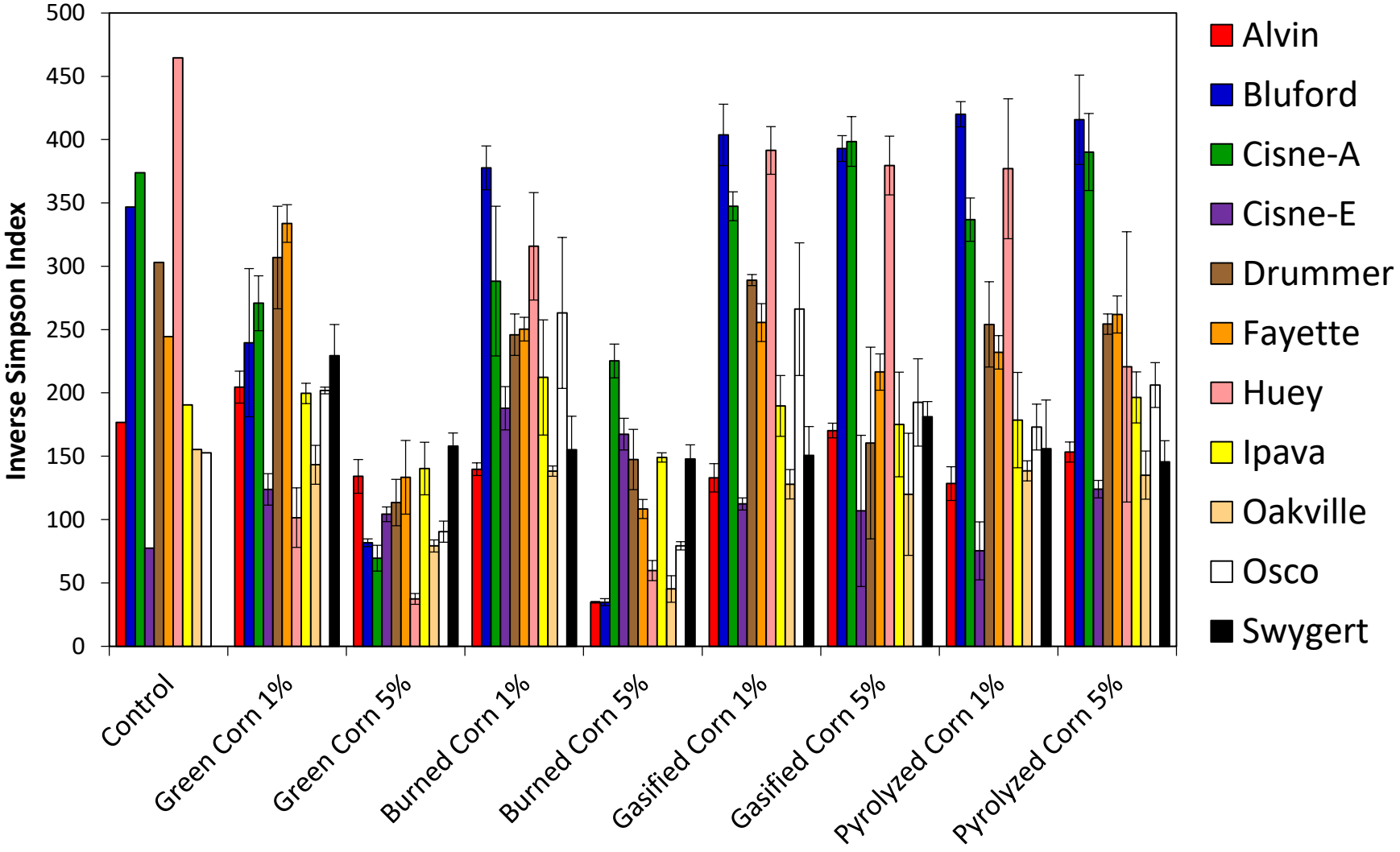
Effect of Gasified Corn Stover for All Soils



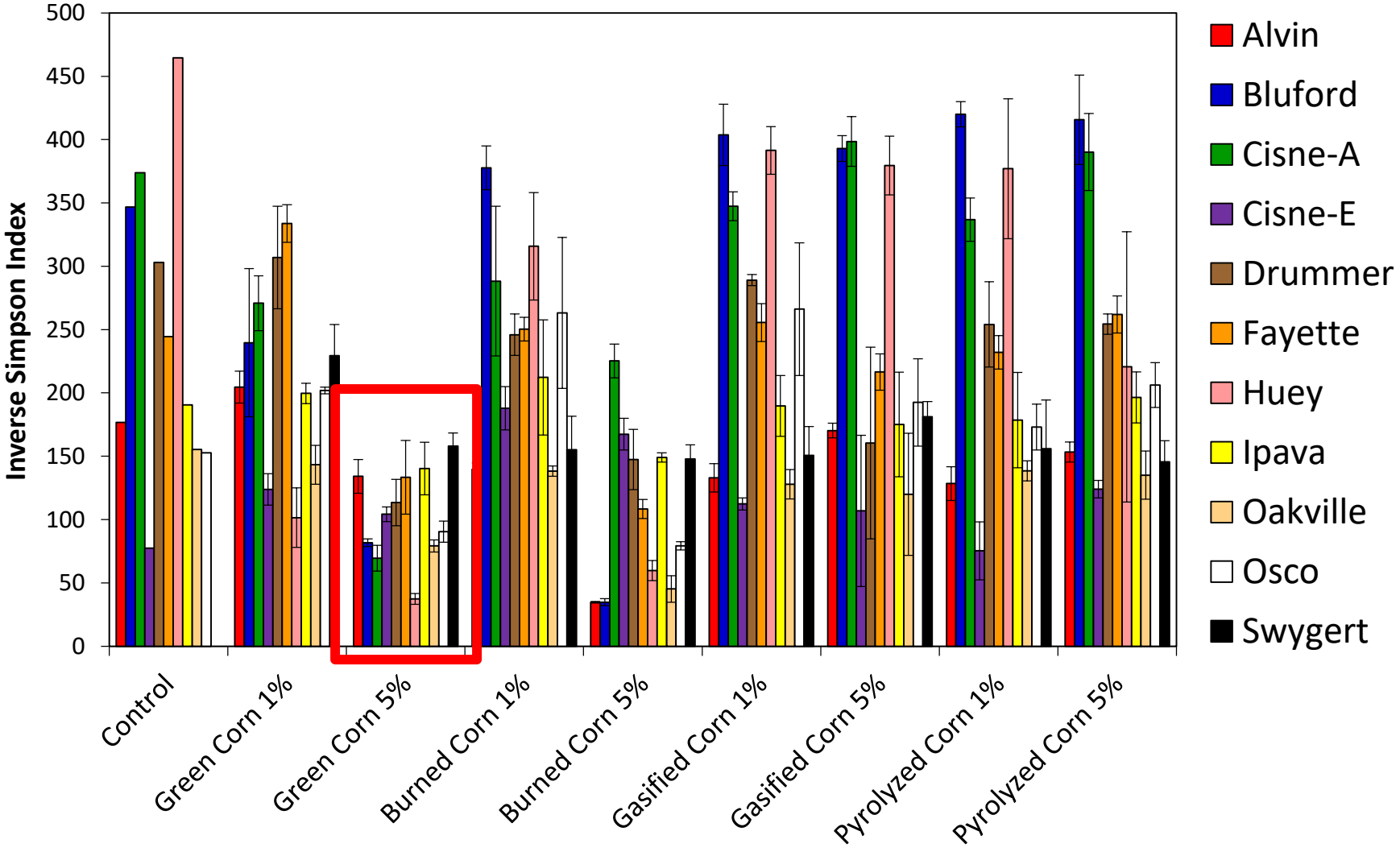
Effect of Pyrolyzed Corn Stover for All Soils



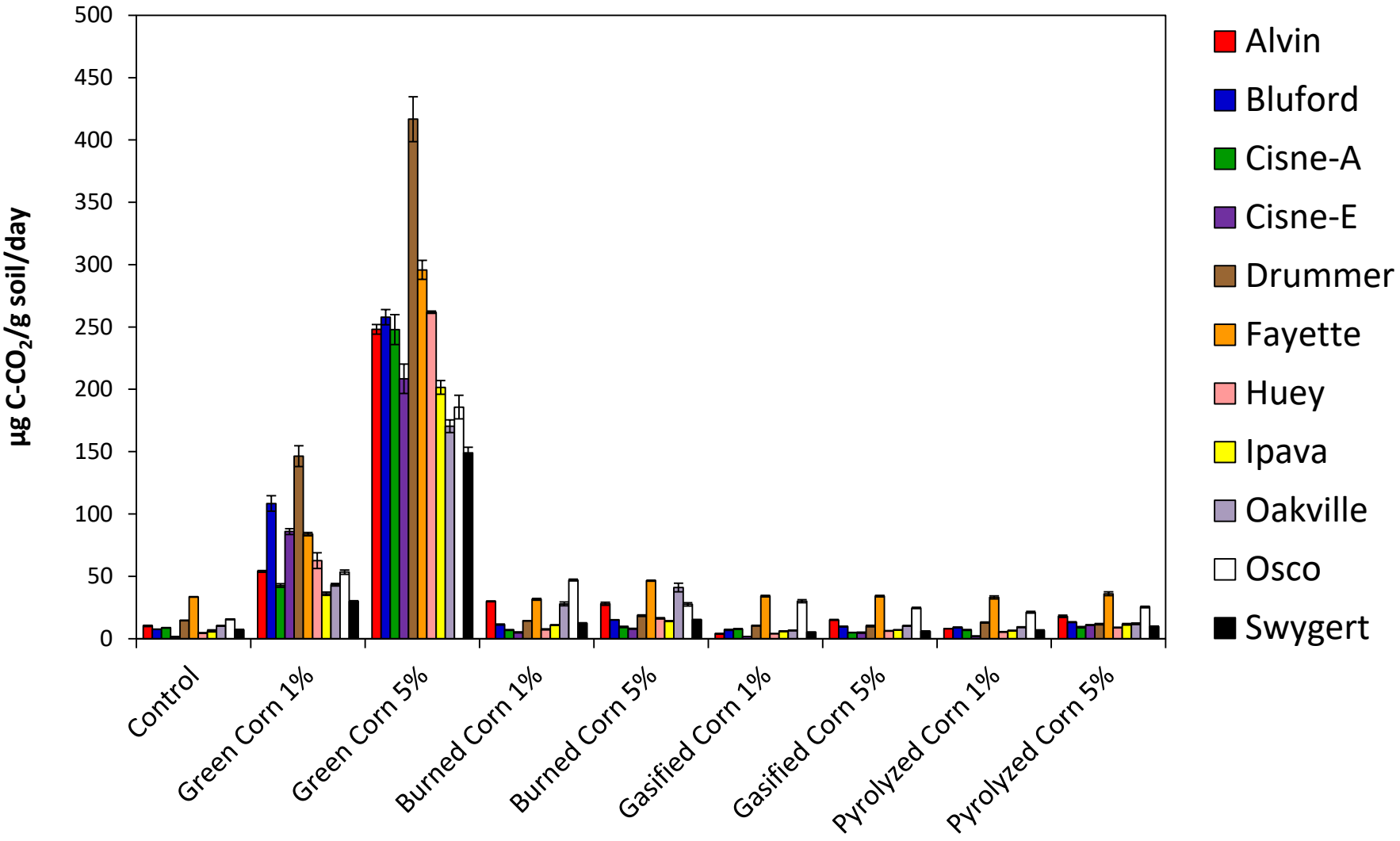
Bacterial Diversity



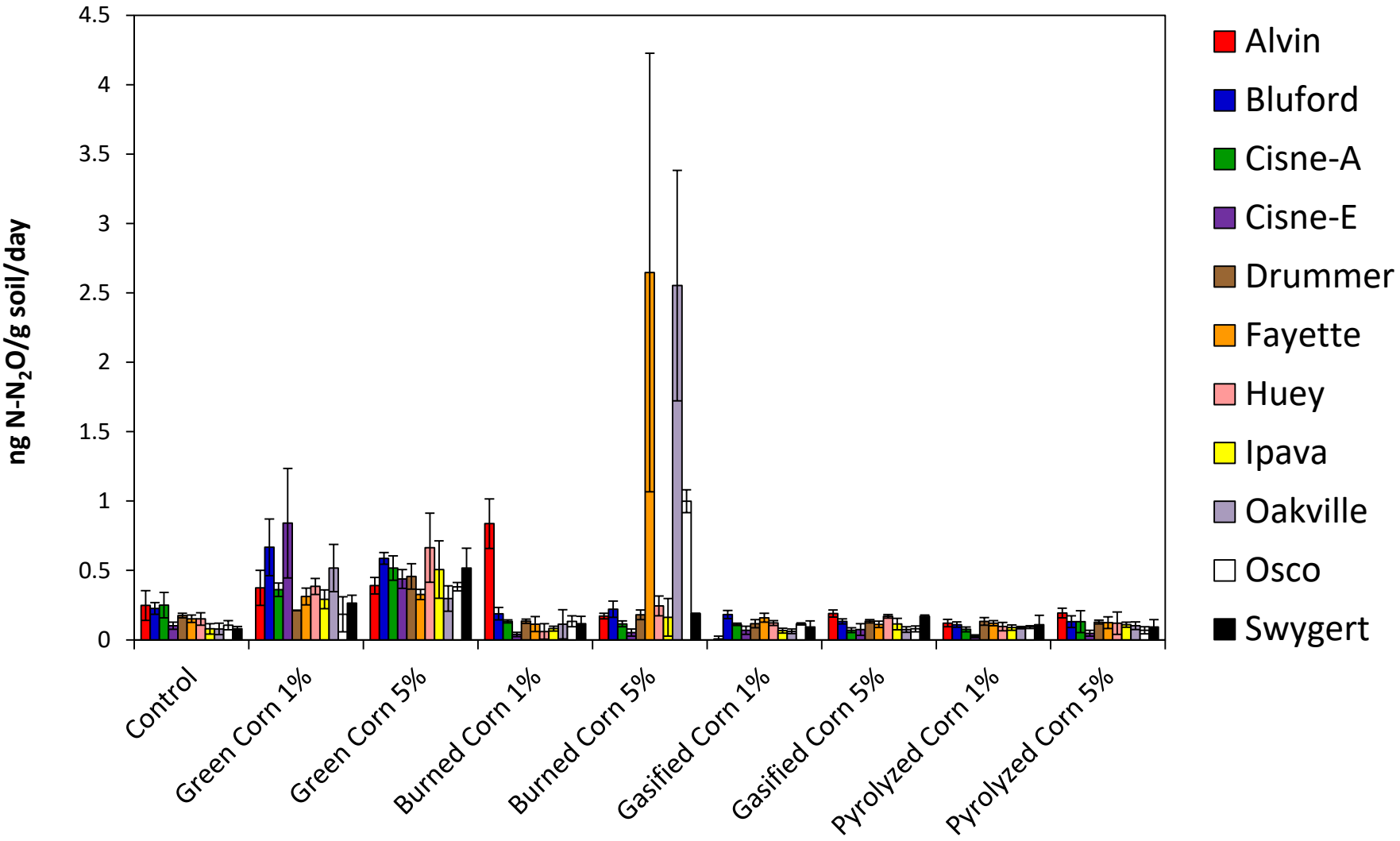
Bacterial Diversity



CO_2 Flux


µg C-CO2/g soil/day
500
450
400
350
300
250
200
150
100
50
0
Control
Green Corn 1%
Green Corn 5%
Burned Corn 1%
Burned Corn 5%
Gasified Corn 1%
Gasified Corn 5%
Pyrolyzed Corn 1%
Pyrolyzed Corn 5%
Alvin
Bluford
Cisne-A
Cisne-E
Drummer
Fayette
Huey
Ipava
Oakville
Osco
Swygert

N_2O Flux


ng N-N2O/g soil/day
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Control
Green Corn 1%
Green Corn 5%
Burned Corn 1%
Burned Corn 5%
Gasified Corn 1%
Gasified Corn 5%
Pyrolyzed Corn 1%
Pyrolyzed Corn 5%
Alvin
Bluford
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Cisne-E
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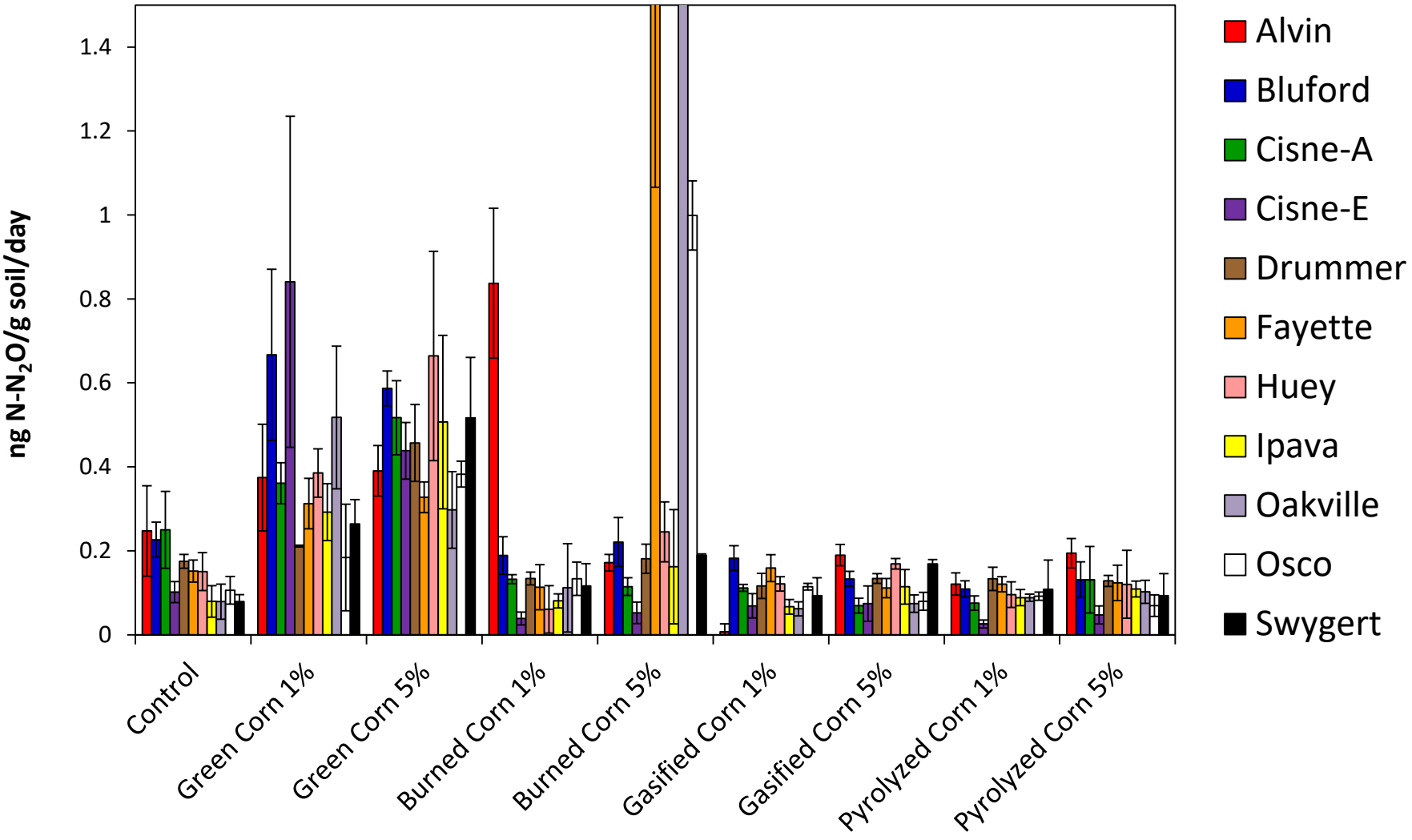
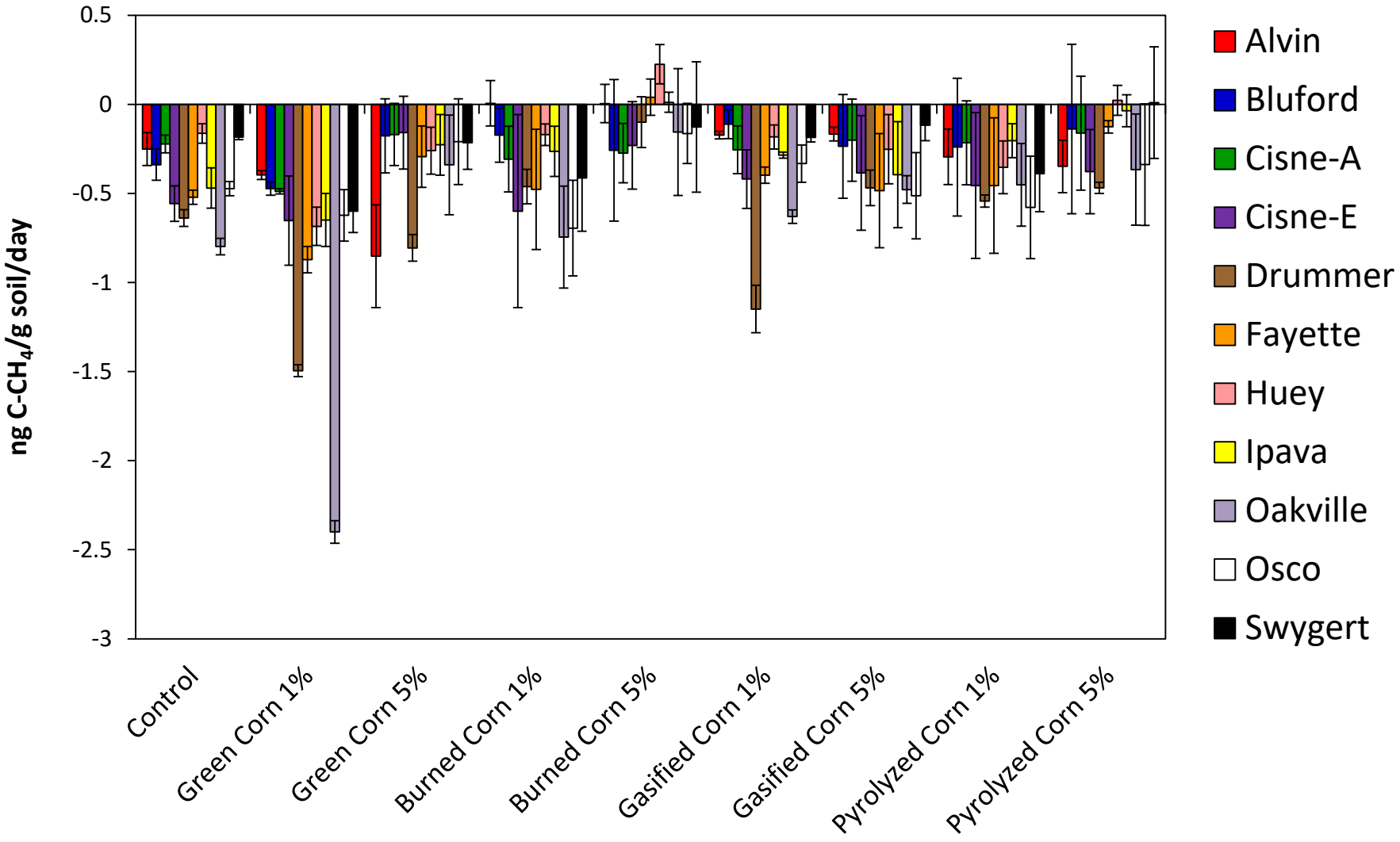
N_2O Flux


ng N-N2O/g soil/day
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Control
Green Corn 1%
Green Corn 5%
Burned Corn 1%
Burned Corn 5%
Gasified Corn 1%
Gasified Corn 5%
Pyrolyzed Corn 1%
Pyrolyzed Corn 5%
Alvin
Bluford
Cisne-A
Cisne-E
Drummer
Fayette
Huey
Ipava
Oakville
Osco
Swygert

CH_4 Flux


0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
ng C-CH4/g soil/day
Control
Green Corn 1%
Green Corn 5%
Burned Corn 1%
Burned Corn 5%
Gasified Corn 1%
Gasified Corn 5%
Pyrolyzed Corn 1%
Pyrolyzed Corn 5%
Alvin
Bluford
Cisne-A
Cisne-E
Drummer
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Oakville
Osco
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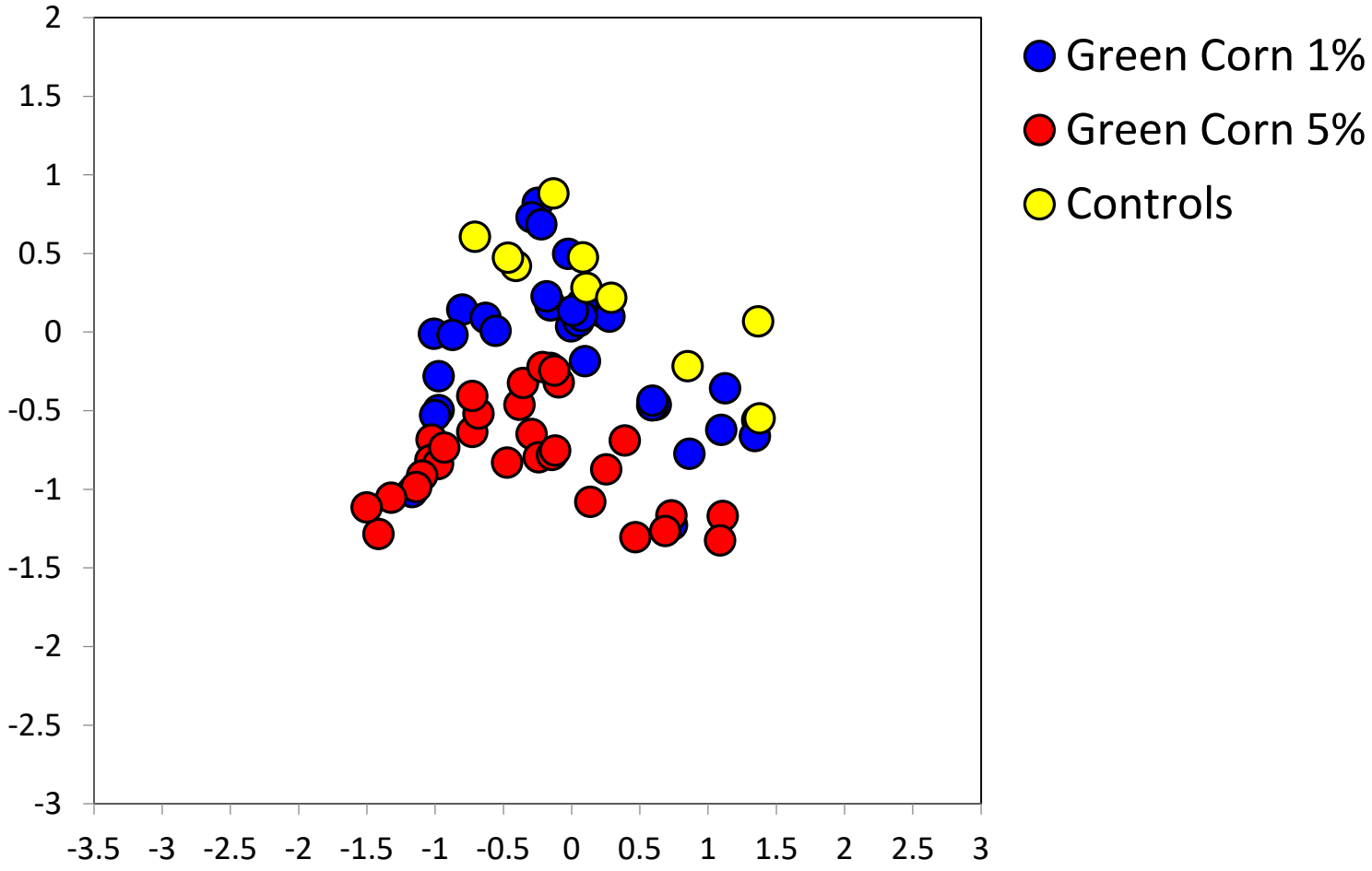

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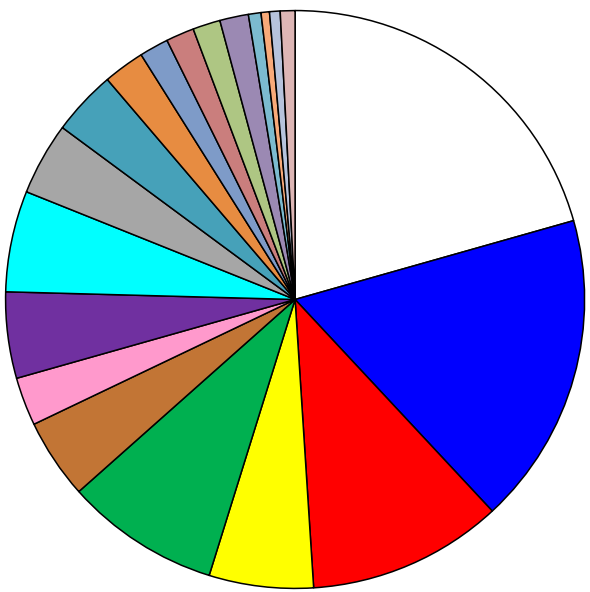
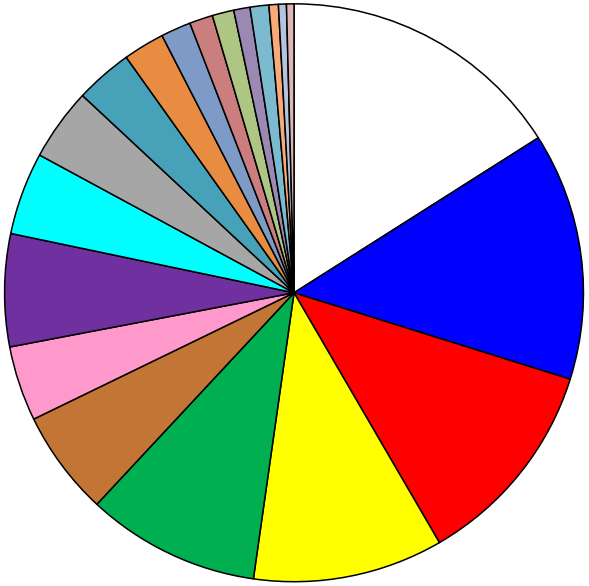
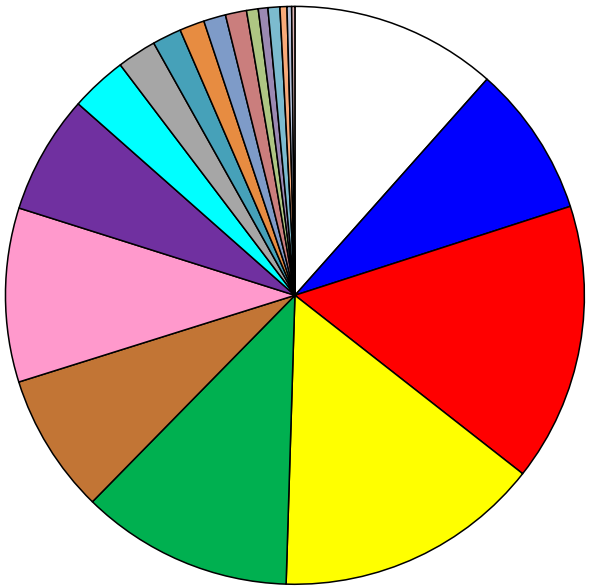


1% Corn



5% Corn

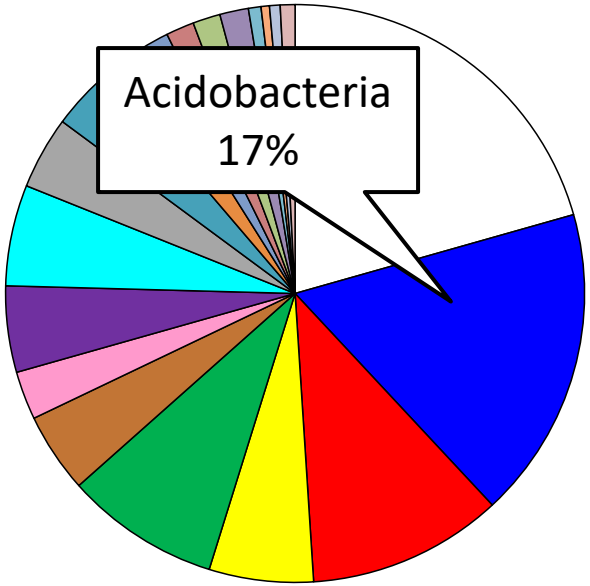


20 Most Abundant Bacterial Classes

- Unclass Bacteria
- Acidobacteria
- Alphaproteobacteria
- Sphingobacteria
- Actinobacteria
- Gammaproteobacteria
- Bacilli
- Betaproteobacteria
- Spartobacteria
- Deltaproteobacteria
- Verrucomicrobia Sub3
- Unclass Bacteroidetes
- Unclass Proteobacteria
- Planctomycetacia
- Gemmatimonadetes
- Ktedonobacteria
- Bacteroidetes
- Opitutae
- Unclass Chloroflexi
- Nitrospira

Effect of Green Corn Stover for All Soils

Control



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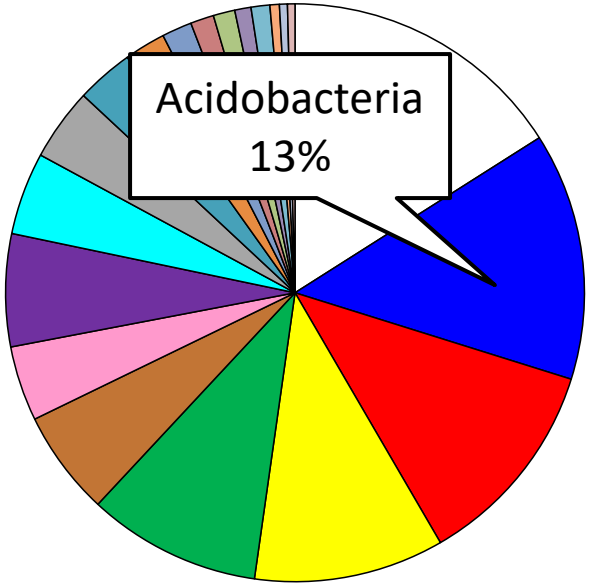

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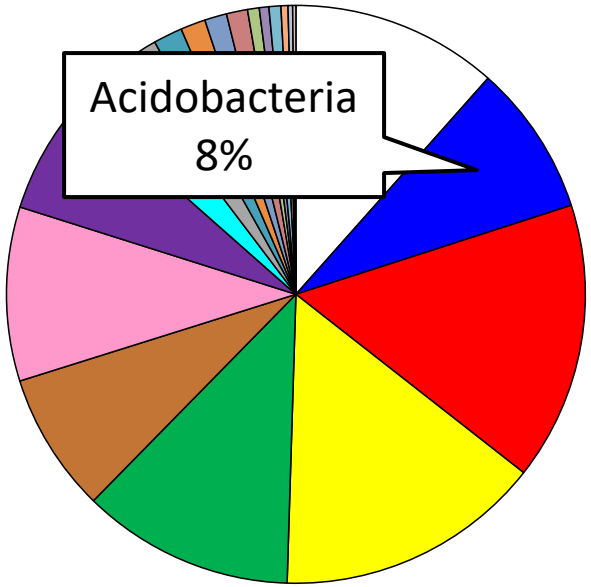

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Spartobacteria	Deltaproteobacteria	Verrucomicrobia Sub3	Unclass Bacteroidetes
Unclass Proteobacteria	Planctomycetacia	Gemmatimonadetes	Ktedonobacteria
Bacteroidetes	Opitutae	Unclass Chloroflexi	Nitrospira

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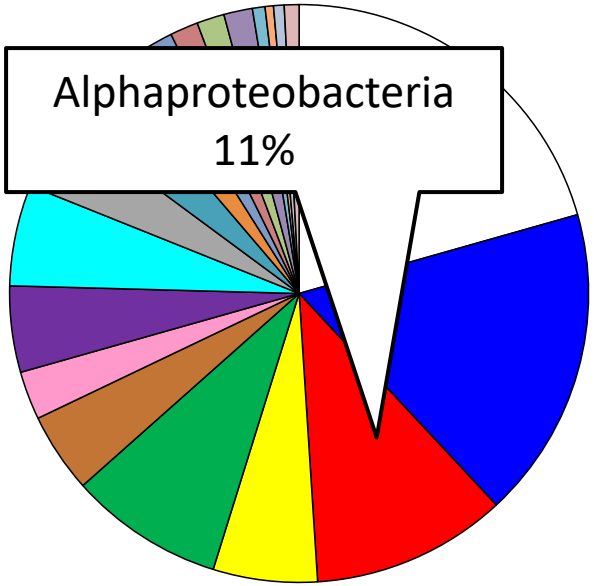
Control



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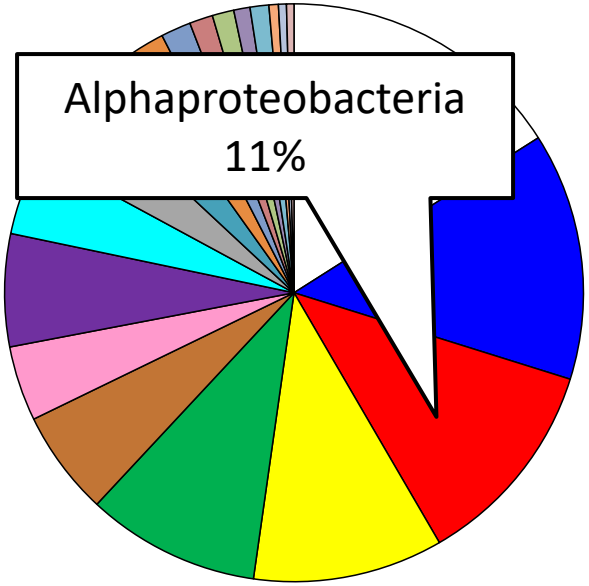

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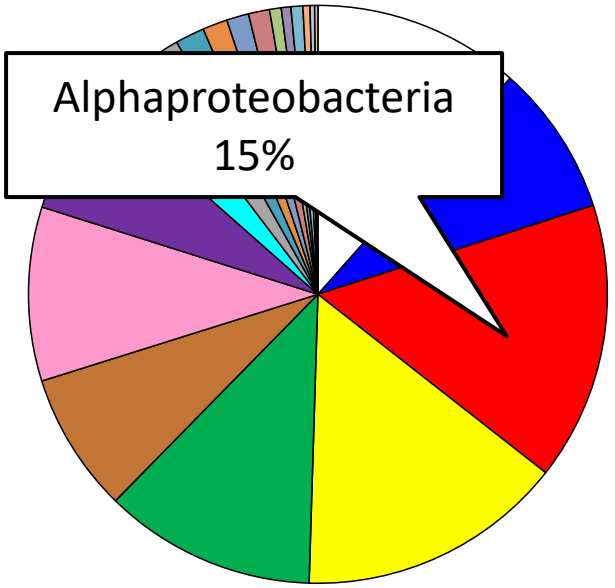

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- Gemmatimonadetes
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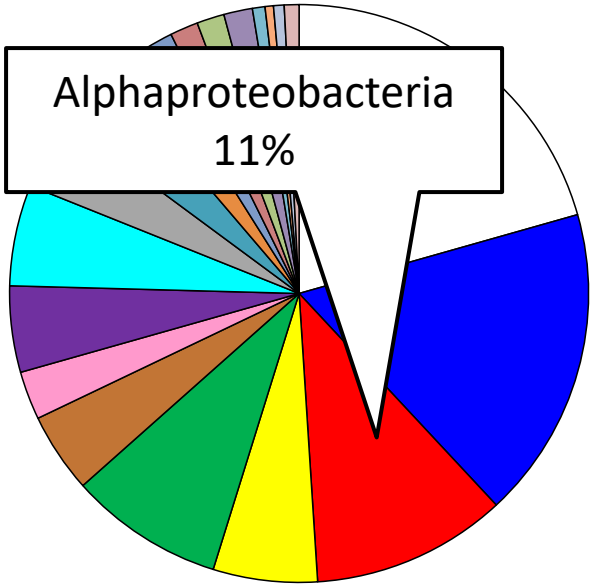

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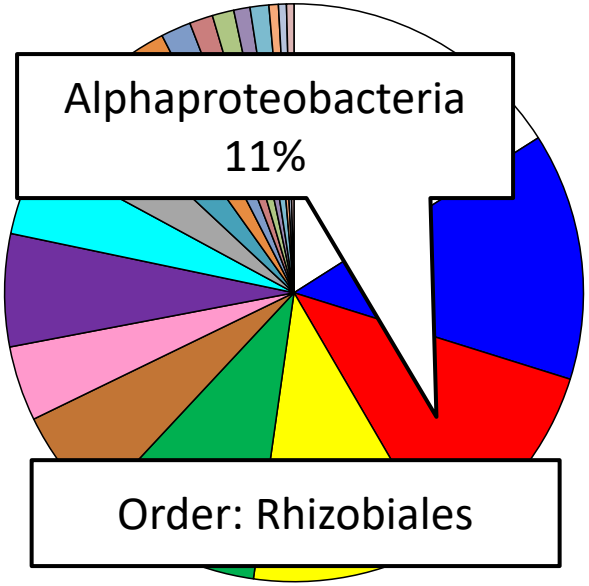

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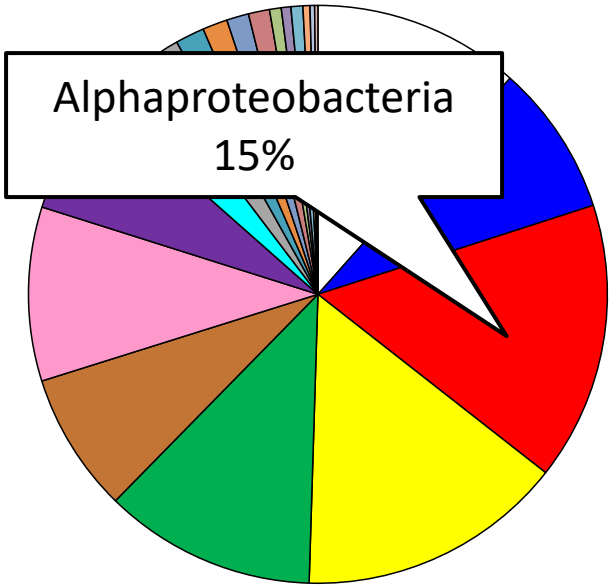

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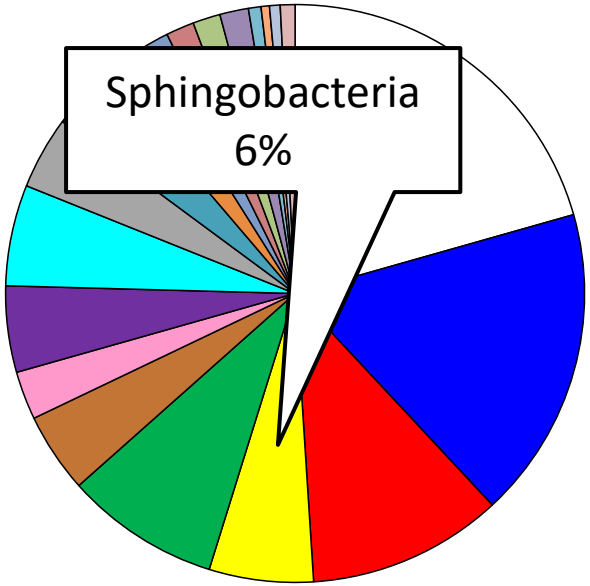

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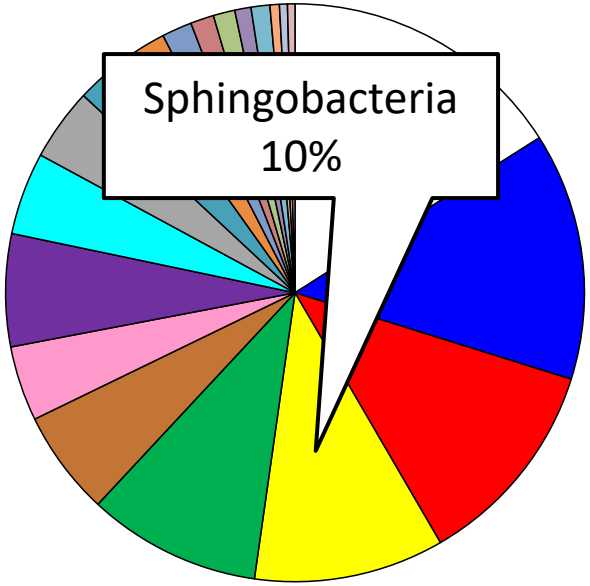

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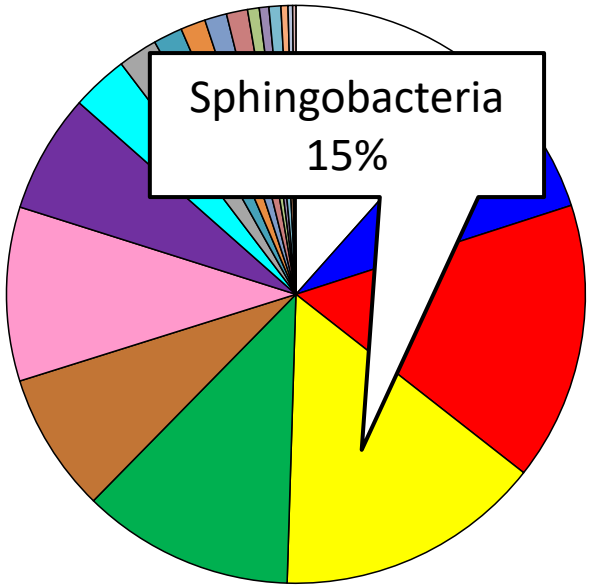

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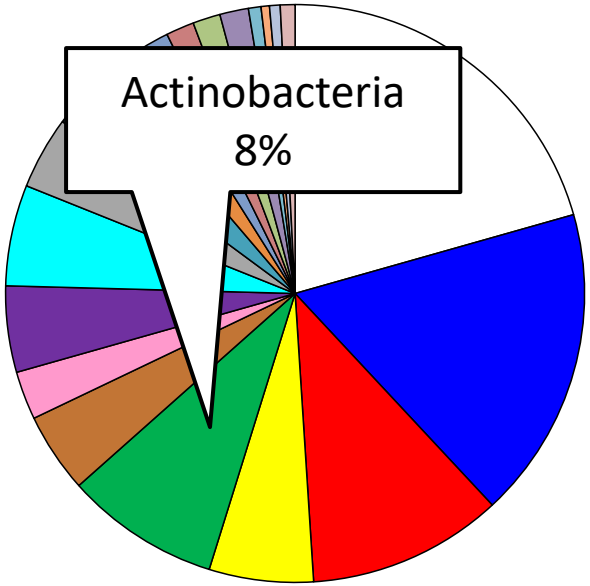

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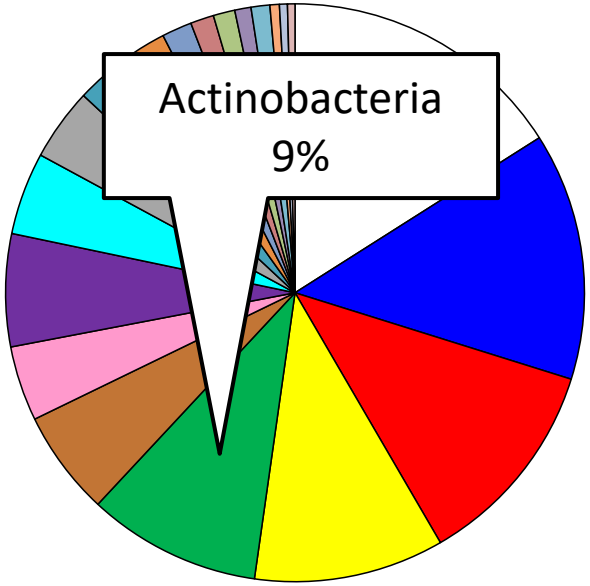

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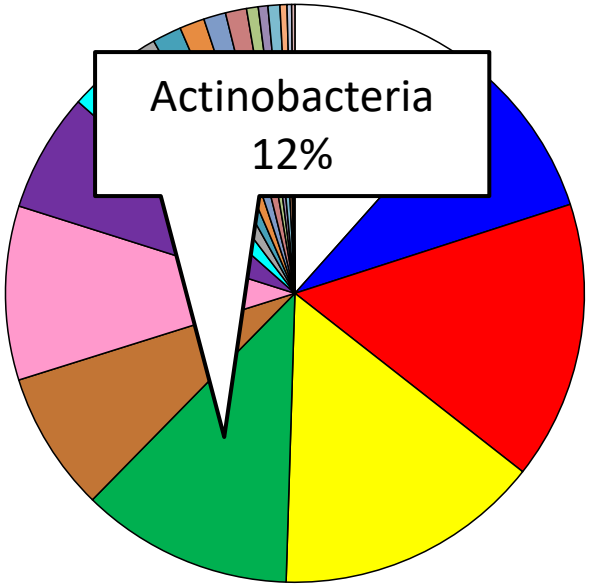

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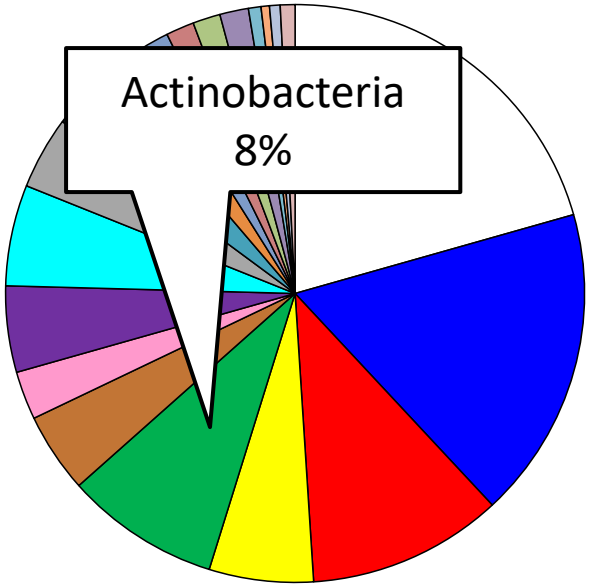
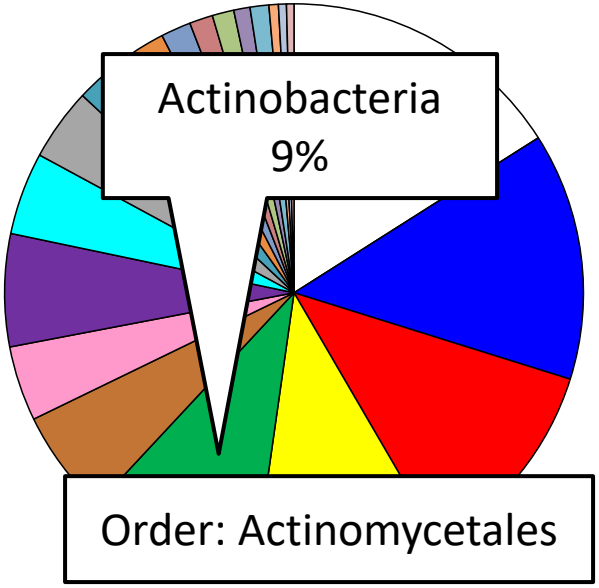
Effect of Green Corn Stover for All Soils

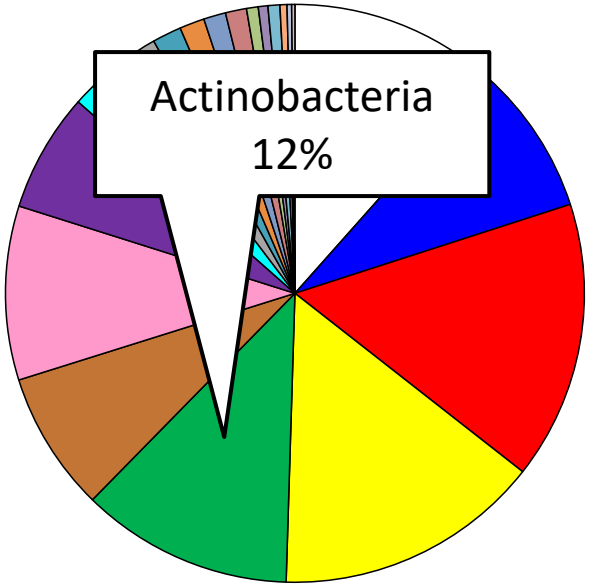
Control



1% Corn



5% Corn



20 Most Abundant Bacterial Classes

Unclass Bacteria	Acidobacteria	Alphaproteobacteria	Sphingobacteria
Actinobacteria	Gammaproteobacteria	Bacilli	Betaproteobacteria
Spartobacteria	Deltaproteobacteria	Verrucomicrobia Sub3	Unclass Bacteroidetes
Unclass Proteobacteria	Planctomycetacia	Gemmatimonadetes	Ktedonobacteria
Bacteroidetes	Opitutae	Unclass Chloroflexi	Nitrospira

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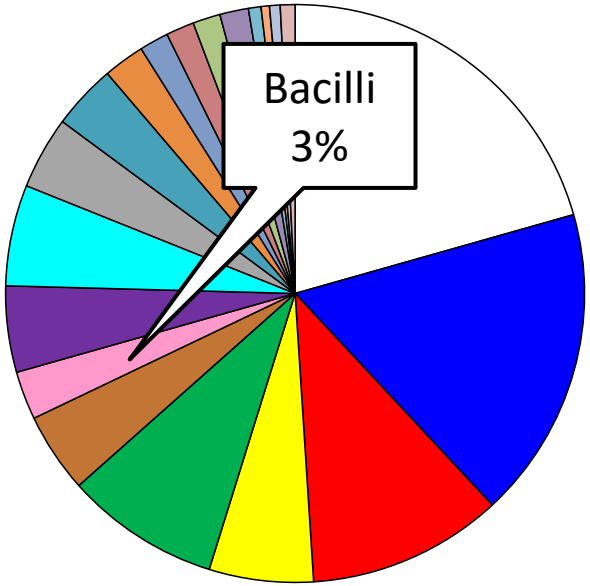
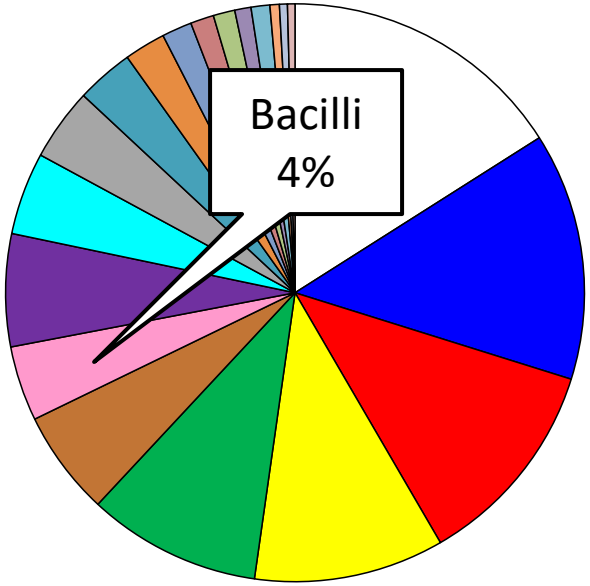


1% Corn



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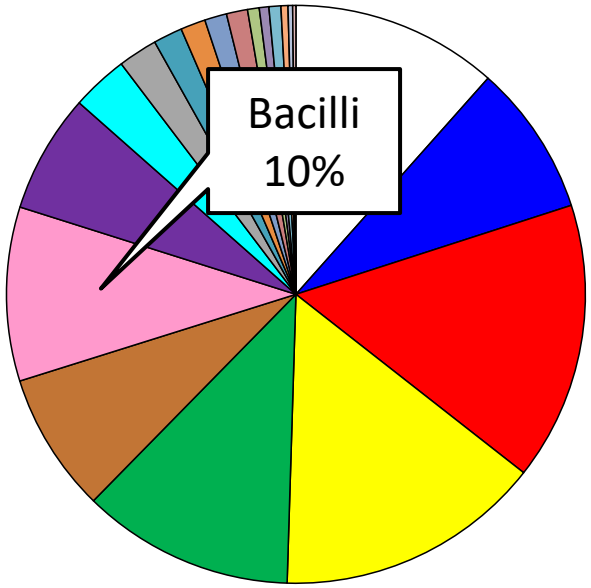

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Summary

- The addition of unmodified corn stover to soils resulted in
  - Increase in CO_2 and N_2O flux
  - Shift in bacterial community composition
- Conversion of corn stover to biochar prevented these effects